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<p>(54) Title: POWER SUPPLY FOR PRIVATE BRANCH EXCHANGE</p>			
<p>(57) Abstract</p> <p>A power supply (20) for a private branch exchange includes a regulator (28) including power factor correction. The power supply also includes a backup battery (50) and flyback power converter (30) which is only connected to the main power source after an initial power level is reached following power-up. A monitor also regulates battery charging from the main power source as a function of temperature. A ringing signal generator (39) is provided by totem pole connected MOSFETs connected to a control circuit which controls the ringing cycle. Current limiting is provided on some supply voltage output (Vout).</p>			

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POWER SUPPLY FOR PRIVATE BRANCH EXCHANGEBACKGROUND OF THE INVENTION

The present invention pertains to power supplies for private exchanges, and more particularly to a power supply supplying power to a private exchange effecting digital signal telephone services at a subscriber premises.

Recently, United States telephone service suppliers have invested billions of dollars developing and installing central office switching equipment, software, and human resources to enable the widespread utilization of digital networks, such as the Integrated Services Digital Network (ISDN). However, user acceptance of digital network telephone services has been minimal. The primary reason for this lack of acceptance of the digital networks is the incompatibility of most telephone customer's existing Plain Old Telephone Service (POTS) subscriber station equipment with the new digital networks. An additional impediment to adoption of the digital network is the high cost of obtaining customer premises equipment compatible with the new digital systems.

Known private exchanges providing digital telephone services at a subscriber premises are typically complex and very costly, requiring a multitude of power supply functions or they are very limited in their utility. Accordingly, despite the large investment and significant effort already expended in providing digital telephone networks, it remains necessary to provide an effective, low cost private exchange which interfaces between the digital network local exchange and plain old telephone service subscriber equipment.

The power supply is a significant consideration in implementing a highly effective private exchange. The digital exchange must perform all of the requirements necessary for a local exchange of the digital network. For example, in the case of an ISDN private exchange, the private exchange must incorporate all of the CCITT reference model NT-1 and power supply functions. However, in providing a local exchange servicing a very limited number of subscriber devices, the cost of the power supply represents a major share of the total cost of the circuits required to manufacture the exchange. Accordingly, there is a need for a more effective power supply for implementing a digital private exchange servicing all types of POTS analog and digital devices using a limited number of ports.

SUMMARY OF THE INVENTION

The present invention overcomes the difficulties of prior art power supplies by providing a more effective power supply than heretofore available which generates the supply voltage output levels and signals for digital network private exchanges.

5 According to one aspect of the present invention, a power supply for a digital network private exchange includes an input connectable to a standard AC wall outlet having a potential less than approximately 240 volts or a standard DC power supply having a potential less than 40 volts. A power converter is connected to the input to receive the source signal, and includes a first PWM controller having a power factor
10 correction such that the power converter maximizes the power available from the power source. A supply regulator is coupled to the output of the power converter for generating regulated output voltages from the preregulated supply voltage.

According to another aspect of the invention, the private exchange includes a main power source and a backup battery source. A switch is connected to the output of the
15 main power source and to the backup battery. The selector selectively couples the main power source to the battery. A circuit coupled to the output of the power source generates an output signal which controls the switch to disconnect the battery from the power supply upon power-up of the main power source.

According to another aspect of the invention, a power supply for a digital network
20 private exchange includes a switched power converter coupled to the power source for generating a regulated output voltage from the source voltage. The power converter includes a switch and at least one storage component for generating a regulated output signal, wherein the switch is controlled as a function of a control frequency. The control frequency is phase-locked to a network wide clock signal.

25 According to yet another aspect of the invention, the power supply includes a temperature sensor for detecting an ambient temperature and a regulator coupled to the temperature sensor. The regulator is coupled to a backup power source for regulating the battery charging voltage as a function of the measured temperature so as to maximize the life of the battery. According to one aspect of the invention, the regulator can include a
30 current sink coupled to the battery.

According to still another aspect of the invention, the power supply for the digital network private exchange includes a controller for selectively turning off functions thereby

conserving the backup battery while permitting network communication functions, when the backup battery is utilized to power the private exchange.

According to one other aspect of the present invention, a power supply includes a current and voltage regulation circuit coupled to the power source for producing the plurality of supply voltage outputs. A control circuit is coupled to the regulation circuit to vary the regulation circuit outputs according to internal or external conditions. According to an aspect of the invention, the power source adjusts some of the supply voltages depending upon which power source is supplying power to the power supply. According to another aspect of the invention, the control circuit controls the regulation circuit 10 according to the load conditions at the output of the power supply.

According to yet another aspect of the invention, a power supply for a private exchange includes a power source generating a regulated positive DC output signal and a regulated negative DC supply voltage. A digital signal generator has first and second digital outputs with first and second control signals thereon. First and second optical 15 couplers connect the first and second output voltages to the digital signal generator. Totem pole transistors are connected to the outputs of the optical couplers for synthesizing a sinusoidal ringing signal at the junction of the transistors.

The present invention provides a power supply which effectively generates supply voltages and control signals required to implement a digital network private exchange. 20 The system is highly functional and interfaces with the private exchange core controller to effect these operations. Furthermore, the power supply is effective in both main power source supply and backup power source supply situations, such that the private exchange may continue to operate even if the main power source is lost. This power supply is set up to maximize the life of the battery if the main power source is lost.

An important element of the present invention is the means by which the cost of providing all of the services is minimized, thereby minimizing the cost of providing all of the necessary signaling and control functions. This facilitates the manufacturing of low cost, fully functional digital network private exchanges, thereby eliminating the perceived cost and compatibility barriers which are currently an impediment to widespread adoption 25 30 of digital network services, such as ISDN basic rate interface implementation.

These and other aspects, features and advantages of the present invention will become clear upon reading the ensuing written description with reference to the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is circuit schematic in block diagram form of a power supply system according to the invention; and

Fig. 2 is a detailed circuit diagram of the power supply according to Fig. 1.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A power supply 20 for a private exchange is coupled to an AC wall outlet 22 as illustrated in Fig. 1. The power supply has a main power source input circuit 24 including a low voltage wall transformer 26 and an AC/DC converter 28. The AC/DC converter 28 produces a DC voltage on supply rail 29, which supplies a preregulated supply voltage to 10 the flyback pulse-width-modulator (PWM) converter 30 and a flyback PWM converter 32. Flyback PWM converters 30 and 32 are selectively connected to the output voltage of the AC/DC converter 28 through a switch 34. Switch 34 is controlled to connect terminal 29 to the PWMs 30 and 32 only after an initial main source power level is reached after 15 power-up of the power supply 20. The power supply also includes a backup power source battery B500. The backup power source battery B500 is connected to terminal 29 through a switch 36. A current sink 37 is connected to battery B500 to regulate the charging current therethrough. A monitoring circuit 38 is coupled to output of the supply terminal 29 to monitor the power on that terminal. The monitoring circuit 38 generates control signals BSTAT1 and BSTAT2 for use in the power supply 20 and the private exchange 20 controller. The monitor circuit also supplies a current sink control signal for regulating the current drawn through the battery B500. A ringing signal generator 39 is coupled to flyback PWM converter 32 and generates a sinusoidal ringing signals under the control of 25 a digital waveform generator 40. The power supply 20 also includes a timing signal generator 41 which outputs clock signals for the flyback power converters 30 and 32 responsive to the private exchange clock signals such that the PWM clock signals input to the PWM converters are in phase with the network data from the local exchange. A 30 switch 42 is connected between the output of clock signal generator 41 and PWM converter 32 to selectively enable this PWM such that it is only operational when the ringing signal is generated while the backup battery B500 is the source for the power supply.

More particularly, wall outlet transformer 26 is a class 1 transformer which connects to a conventional 110 VAC wall outlet 22 and produces a low voltage AC power output. The wall outlet transformer 26 generates an output voltage having a magnitude of

approximately 6 to 11 VAC. Alternatively, an 11 to 15 VDC potential may be used as the main power source, (e.g., a large backup battery system). The wall transformer 26 is connected through a coaxial connector J6 to terminals 50 (Fig. 2) and 51. A transformer T502 is connected to terminals 50 and 51. Transformer T502 includes a coil 52 connected 5 between terminal 50 and a terminal 56, and a coil 54 connected between terminal 51 and a terminal 58. Transformer T502 is a common mode filter which filters high frequency noise. A pair of Zener diodes D520 and D521 are connected in series between terminals 56 and 58. These Zener diodes provide protection against high voltage AC transients. Terminals 56 and 58 are connected through a diode bridge 60 to output terminals 62 and 10 64. The diode bridge 60 includes four Schottky diodes D522, D523, D524 and D525 which provide full wave rectification between input terminals 56 and 58 and output terminals 62 and 64.

A capacitor C530 is connected between the positive terminal 62 and the negative terminal 64 of rectifier bridge 60. Capacitor C530 has a low value, which may for 15 example be approximately 5 uF, such that it does not provide high level filtering. Rather, the impedance of capacitor C530 is uniquely selected to provide low source impedance to the high frequency input circuit such that the voltage across capacitor C530 will closely resemble a full wave rectified sinusoidal signal.

An inductor L500 is connected between terminal 62 and the anode of a Schottky 20 diode D526. The cathode of Schottky diode D526 is connected to the positive plate of a capacitor C531. A MOSFET element Q525 has a drain connected to the anode of diode D526 and a source connected to ground. The inductor L500, the transistor Q525, and the capacitor C531 provide a boost-type switchmode power supply which stores power in inductor L500 and capacitor C531 under the control of MOSFET element Q525. A pulse- 25 width-modulator controller U500 controls the MOSFET Q525. The pulse-width-modulator controller includes a power factor correction. Although integrated circuit U500 may be implemented using any suitable pulse-width-modulator, it is preferably implemented using a commercially available UC3854BN integrated circuit having power factor correction. Pin 15 of integrated circuit U500 is the supply voltage input, and is connected to inductor 30 L500 by diode D528, and is connected to capacitors C556, C511, C560 and resistor R503. The voltage sense input pin 11 of integrated circuit U500 is connected to the junction of resistors R519 and R574 which is a voltage divider connected across output capacitor C531. A feedback path between pin 11 and output pin 7 is provided by the parallel

connection of resistor R517 and capacitor C523. AC current input pin 6 is connected to capacitor C553 and to terminal 62 through resistor R529 and supplies the input waveform to synthesize the resistive load to the input supply. Capacitor C553 filters the signal on pin 6. Pin 6 is also biased through a resistor R518 to the reference pin 9. The average 5 input voltage is connected to voltage input pin 8 at the junction of resistor R528 and a capacitor C525 by a resistor R514. A current sense pin 4 is connected to circuit ground through a resistor R585 and to output pin 3 through feedback capacitors C534, C542 and resistor R555. The peak limit input pin 2 is connected to the negative terminal of bridge 10 60 through resistor R581. Pin 2 is also connected to the reference voltage at pin 9 through resistor R565 and to ground through capacitor C545. The voltage across resistor R591 is supplied through resistor R564 to pin 2 of IC U500. The enable pin 10 of integrated circuit U500 is connected to the supply voltage pin 15 through a resistor R530. Pins 13, 12 and 14 of integrated circuit U500 are connected to ground through capacitor C521, resistor R524, and capacitor C533, respectively. Output pin 16 of the pulse-width- 15 modulator controller is connected through a resistor R537 to the gate input of transistor Q525. A Schottky diode D556 is connected to output pin 16 to limit the output signal undershoot.

In operation, integrated circuit U500 outputs a signal at output pin 16 which turns transistor Q525 on. While transistor Q525 is conductive, a current ramps up through 20 inductor L500 until a current threshold is reached. The current is determined by the load demand and the instantaneous voltage across capacitor C530. When the voltage across resistor R591 reaches a predetermined limit, the output at pin 16 of the integrated circuit U500 drops to a level which turns transistor Q525 off. The current flowing into inductor L500 then flows through diode D526 and charges capacitor C531. Simultaneously, current 25 flows through diode D528 to capacitor C556. The voltage developed on capacitor C556 provides an isolated power supply for integrated circuit U500. The cycle repeats at a high frequency set by capacitor C533 and elements within integrated circuit U500. For example, capacitor C533 has a capacitance of approximately 470 pF.

The pulse-width-modulator integrated circuit U500 includes a power factor circuit. 30 Although this IC is manufactured for use with very large amplitude power supplies, it is uniquely applied to the low level 6-11 VAC signal output by the wall transformer 26 (Fig. 1) in the present invention, to provide a more efficient power draw and to maximize the performance of low-cost transformer components while providing a pre-regulated voltage

at junction 29 for the following circuits, thereby providing a more cost effective power supply.

The power supply 20 includes a systematic power-on and power-off control circuit 68. Control circuit 68 includes a MOSFET switch Q527 having a source connected to terminal 29 and a drain connected to the battery B500. The MOSFET switch Q527 is controlled to connect the battery B500 to terminal 29. The gate of MOSFET Q527 is connected to terminal 29 through the parallel connection of a resistor R604 and a capacitor C557. The gate of MOSFET Q527 is also connected to the output of PWM controller U515 through a charge pump 70 including diodes D568 and D569 and capacitor C552.

10 The negative terminal of battery B500 is connected through a fuse F500 to the anode of a Schottky diode D527, the cathode of which is connected to ground. The junction of diode D527 and fuse F500 is connected to the current sink 37, which is implemented by a transistor Q502 and a resistor R542 connected to ground.

The systematic power-on and power-off 68 also includes a Darlington transistor switch Q524 having a base connected through a resistor R532 to the collector of a transistor Q512. The base of transistor Q512 is, in turn, connected through a resistor R545, capacitors C546 and C567, and the parallel connection of a diode D570 and a resistor R605 to the VCC supply voltage for integrated circuit U500. When the connector J6 is connected to a main AC power supply, power is delivered to VCC input pin 15 of integrated circuit U500. At turn on, this voltage rises from an initial level near ground to a level of approximately 17 VDC. When it reaches 17 VDC, current is supplied to the base of transistor Q512 through diode D570, capacitor C546 and resistor R545. This current will continue to flow until capacitor C546 is fully charged, which will take from one to two seconds. This provides the power-up "kickstart" and operation is continued by the KEEPOON signal from the microprocessor system. Transistor Q512, in turn, drives the base of transistor Q524 through resistor R532. When Darlington switch Q524 is turned on, the voltage on supply rail 29 is input to the VCC input pin 7 of integrated circuits U515 and U516.

The transistor Q527 is initially off when a charged battery B500 is connected to the power converter 20, which is not powered through connector J6 (i.e., battery B500 has a charge and connector J6 is not connected to an AC or DC power supply). Transistor Q527 is turned off to prevent a current surge from the battery B500 flowing into capacitor C531, a high capacitance, filter capacitor. If such a surge were to occur, the circuit

component could be damaged and fuse 500 would interrupt the power supply, requiring repair of the circuit.. When the power supply 22 builds up to a sufficient level to turn switch Q524 on, the output voltage at pin 6 of integrated circuit U515 will supply power to rail 29 and the gate of MOSFET Q527. The battery will charge from rail 29 when
5 MOSFET Q527 conducts through transistor Q502.

The systematic power-on and power-off circuit 68 also includes a resistor R599 connected between the base of transistor switch Q528 and the base of transistor switch Q524. The emitter of transistor Q528 is connected to supply rail 29 and the collector of transistor Q528 is connected to a resistor voltage divider 72. The voltage divider includes
10 resistors R551, R500, R552, thermistor R549, resistor 526 and resistor 547. Transistor Q527 supplies energizing current to the resistor divider 72 when transistor Q512 supplies base drive current to transistor Q527.

The current mode flyback power converter 30 is connected to supply rail 29 through transistor switch Q524 and generates output signals of 5 volts, ± 13 volts, +6.5 volts, -8
15 volts, -28 volts and -43 when transistor Q524 is "on." The flyback power supply 30 uses integrated circuit U515 as the PWM controller. These voltages are used by the main processing unit in the private exchange as well as other logic circuits in the private exchange. The clock to the pulse-width-modulator is driven by a 64 KHz signal derived from the phase lock loop circuit U512 and output at pin 11 of IC U514. The PWM 30 includes Darlington pair transistor Q522 having a base drive signal filtered by capacitor
20 C547 and resistor R512, and provides a soft-start function for the PWM. This prevents PWM controller U515 from going into a full duty cycle when initially turned on. Resistor R521 and resistor R520 provide a voltage divider connected between the 5 volt regulated supply output pins 10 and 11 and ground. The junction of these resistors is connected
25 directly to pin 2 which is compared against an internal reference of integrated circuit U515. Resistor R543 and capacitor C537 set the gain and frequency response of the internal error amplifier. The output at pin 6 of integrated circuit U515 is connected through a resistor R538 to the gate of transistor Q509. A Schottky diode D554 is connected between the output pin 6 and ground to catch undershoot at pin 6.

30 When transistor Q509 conducts, it draws current through the primary winding 71 of transformer T500. This current ramps up until the voltage drop across resistor R592 reaches the voltage set in integrated circuit U515 by the internal error amplifier. Resistor R506 and capacitor C543 filter out the turn-on spike of transistor Q509, and pass the ramp

current to the current sense pin 3 of integrated circuit U515. When the current set point is reached, the integrated circuit U515 output on pin 6 is turned off. The energy stored in the core of transformer T500 due to the current through the primary winding is then delivered through the secondary windings of transformer T500 and through diodes D500,

5 D508, D509, D510, D501, D503 and D504, to the appropriate filter capacitors C500, C504, C503, C502, C501, C505 and C549. The secondary windings are scaled to the 5 volt output at pins 10 and 11 of the secondary winding by the feedback to pin 6 such that when the 5 volt supply is within its desired regulation level, all other supplies are at their regulated voltage level.

10 The output section 110 for pulse-width-modulator circuit 30 provides voltage control and current limiting for the ± 12 supplies at pins 15 and 13 of connector J9A. The ± 12 volt supplies are used to provide power to the RS232 drivers in the private exchange. To protect the power supply 20 against external overloads, current limiting for the +12 volt supply is provided by transistors Q526, Q503, and the current limiting for the -12 volt supply is provided by transistors Q500 and Q518. Diodes D532-D534 are connected to the base of transistor Q503 and diodes D535-D537 are connected to the base of transistor Q518. In operation, if a voltage drop of 1 diode (approximately .7 volt) exists across resistor R553, the drive current to the Darlington pair will be shunted by diodes D532-D534, thereby reducing the drive current to the Darlington pair and effecting a current limiting function. Until that 1 diode voltage drop is reached, the Darlington pair will supply and deliver +12 volts to the RS232 drivers without current limiting. The positive and negative 13 volt power supply outputs each supply drive currents for the following transistors Q503, Q528 and Q500, Q518. At least one of these outputs must be fully floating to track the output signal.

25 Activation of the ± 12 volt supplies occurs when EN12V232 at pin 3 of connector J9A goes low. EN12V232 going low drives transistor Q506 through resistor R572 which, in turn, drives transistor Q519 through diodes D542 and resistor R566. Transistor Q519 serves as a signal inverter to drive the Darlington pair connected transistors Q526 and Q503 through resistor R571. Transistor Q506 also enables the -12 volt supply. The 30 transistor Q506 delivers current through resistor R572 to drive the Darlington pair Q500 and Q518 to turn on the -12 volt supply. Just as was the case with the +12 volt supply, should the resulting current through resistor R548 cause a voltage drop in excess of 1

diode drop, the drive current will be shunted by diode D535, diode D536 and diode D537, effecting a current limit for the -12 volt supply.

When the system is operating from standby battery, the ± 12 volt supplies are replaced by ± 6 volt supplies to reduce the power draw nominally by a factor of four, thus limiting the battery usage. To provide this control function, transistors Q506 and Q518 are connected to the gates of each of the current limiting transistor current sources. As described above, the input to these transistors is provided from the EN12V232 pin 3 of connector J9A, which is connected to the private exchange. When the power supply 20 goes to standby battery during a power failure, the microprocessor (not shown) controls signal EN12V232 to have a high logic level. This turns off the ± 12 volt supplies. The outputs 13 and 15 are then coupled to the +6.5 volt supply through diode D546 and to the negative 8 volt supply through diodes D547-D550, respectively. The diode voltage drops across diode D546 and diodes D547-D550 result in supply outputs of approximately ± 6 volts at pins 13 and 15. This is adequate to keep the RS232 drivers operating at a low signal level.

Another small current-limit circuit is provided on the -43 volt output (pin 8 of connector J8A) and formed by transistor Q501, resistor R548 and diodes D538, D539. A Zener diode D558 supplies protection for the -43 volt output against voltages exceeding the reverse breakdown voltage of this Zener diode.

The flyback power converter 32 includes PWM current mode controller U516 and furnishes ± 100 volt supplies and two 13 volt driver supplies for the ringing signal generator 39. It also generates a -41 volt supply for powering the S/T interface modules. The clock signal for effecting operation of the PWM current mode controller 32 is derived from the same external reference frequency as that provided to IC U515. However, to reduce the current peaks of the clock for integrated circuit U516, it is inverted from that used by integrated circuit U515. NANDgate U517B is connected to the reference frequency generator and NANDgate U517A to perform this timing inversion. Additionally, NANDgates U517B and U517A, in conjunction with diode D553, are connected so as to shut down the operation of integrated circuit U516 when the integrated circuit is powered by standby battery, unless the ringing signal generator is needed. This conserves backup battery B500 during the backup power source operation.

The VREF outputs pin 8 of IC U516 and pin 8 of IC U515 are connected to drive a temporary local five volt power supply output through diodes D571 and D531. Schottky

diode D567 feeds this voltage from the system +5 volts when it becomes available. The voltage feedback input pin 2 is connected to the output of an amplifier U507B, which buffers and inverts the -41 volt signal on the secondary side of transformer T501. A soft turn-on is provided by switch Q523, capacitor C548, and resistor R513. The output pin 6 5 of integrated circuit U516 is connected through a resistor R534 to the gate of MOSFET element Q510. MOSFET element Q510 controls the current flow through the primary winding of transformer T501. The current sense input pin 3 of IC U516 is connected to resistor R593 through resistors R507 and capacitor C544. Resistor R507 and capacitor C544 filter out the turn-on current spike.

10 When the MOSFET Q510 is switched off, current flows from the secondary winding 115 through diodes D505, D513, D514, D515 and D507 into the filter capacitors C508, C535, C536, C509, C506 and C507. To allow ring trip detection, the center tap 113 of the secondary winding 115 is connected to the -28 volt supply which provides a DC offset.

15 The ringing signal generator includes a control circuit 40 which outputs timing signals to IC switches U502 and U503. These switches generate the 20 Hz, 63 volt RMS sinusoidal signal to drive the ringer in a POTS phone. The controller 40 includes an IC U508, which is a 74HC164 shift register parallel control providing address signals to IC U509 or IC U510 (only one of which is used). IC U509 is an MA828-2PLABA and IC 20 U510 is an MA838-2PLABA. IC U509 or IC U510 generates the enabling signal input to optical coupler U502 during the positive half of a sine wave and the enabling signal input to optical coupler U503 during the negative half of the sine wave PWM time periods. These output signals are duty-cycle controlled PWM waveforms controlled to synthesize a low frequency waveform. In the preferred embodiment, a 24 KHz PWM waveform is 25 filtered by L501 and C529 to create the 20 Hz sine wave. The output of optical coupler IC U502 is applied to the base of transistors Q513 and Q504 which, in turn, drive the gates of a MOSFET element Q520. The output at pin 13 of integrated circuit U503 drives the bases of buffer transistors Q515 and Q505. They, in turn, drive the gate of MOSFET element Q521. During the positive part of the PWM generation, MOSFET Q520 is driven 30 into conduction by the 24 KHz data stream output by integrated circuit U509 and MOSFET Q521 is driven during the rest of the cycle (less dead time). The MOSFETs are thus switched on and off at a rate which drives the LC filter formed by L501 and capacitor C529. The LC filter removes the 24 KHz switch component and delivers a clean

sine wave. The MOSFET element Q520 and a MOSFET element Q521 are connected in totem pole arrangement. The junction of the MOSFET elements thus have a sinusoidal ringing signal thereon, modulated by the 24 KHz carrier. This is a Class "D" switchmode power amplifier output.

5 A resistor R540 is connected to the source of MOSFET Q520 and a resistor R541 is connected to the source of MOSFET Q521. These resistors are used for current sensing. Should the voltage drop across these resistors exceed the base emitter drop of transistors Q514 and Q516, respectively, transistors Q514 and Q516 will clamp the output of the optocouplers U502 and U503 to limit the current through MOSFETs Q520 and Q521.

10 When the reset of integrated circuit U509/U510 is released at the beginning of a ring cycle, the ring signal output will always start at 0 degrees. At the end of the ring cycle, optotriac U511 is turned on by a phase inverter transistor Q508. Transistor Q508 is driven into conduction when the RINGON control signal goes low which creates a current flow through resistor R590. Resistor R582 limits the input current to the optical coupler
15 TRIAC integrated circuit U511. The output of integrated circuit U511 discharges capacitor C529 through R576, which may have as much as 100 volts across it at the end of the ring cycle. These two actions, along with the appropriate ring insertion delays, reduces the contact wear on the relay which connects the ring voltage to the POTS line.

20 The input signal RINGON to ringing signal controller 40 can be varied to turn the ringing signal on and off at different cadences when different parties are called. This provides distinctive ringing to identify called parties using a common analog line.

25 A protection circuit 120 controls the -41 volt supply used by the external S/T equipment. As with the ± 12 volt supplies and the -43 V supply, the -41 volt supply is affected by conditions outside the private exchange, and therefore needs to be protected against overloads. Transistor Q511 is a series pass element connected between the -41 volt potential and pin 10 of connector J8A to provide this protection. Transistor Q511 is turned on by transistor Q507, which receives the ENSTPWR2 signal. Transistor Q507 is connected to MOSFET element Q511 through a resistor R570 and is enabled when the system is operating from the main power source input 24. It is turned off when the main
30 power source is interrupted such that the power source for the power supply is the standby battery B500. A current sense resistor R539 is connected in series with MOSFET element Q511. If the voltage drop across resistor R539 reaches the base emitter voltage of transistor Q517, current is injected into the base of transistor Q517 through resistor R583.

The collector of transistor Q517 therefore begins to conduct current, reducing the gate drive to MOSFET element Q511. This limits the current through transistor Q511. In the case of an even heavier load on the output, such as occurs in a short circuit condition, which increases the voltage across transistor Q511 to an unsafe level of dissipation, Zener
5 diode D562 begins to conduct and injects additional base current into transistor Q517 through resistor R569. This causes foldback current limiting, as set by resistors R583 and R511, reducing the current through MOSFET Q511 and turning it off, thereby preventing the MOSFET Q511 from overheating. Zener diode D561 controls maximum gate voltage on transistor Q511, while resistor R515 supplies a turn-off bias. Capacitor C507 supplies
10 a surge time-constant for the current limit action. All three are connected from the gate to the most negative voltage. Another capacitor, C534, connects from the output voltage back to the gate of transistor Q511 for negative feedback stabilization.

When the voltage at pins 10 and 11 reaches 5 volts, a master power-on reset takes place within the main microprocessor in the private exchange. This initiates the operation
15 of the main microprocessor. A KEEPON signal is input at pin 4 of connector J9B from the main microprocessor, which connects to transistor Q512 through diode D544 and resistor R586. This signal holds transistors Q524 and Q528 on, and bootstraps the power supply into full operation. Simultaneously, the PWM output at pin 6 of integrated circuit U515 drives a charge pump circuit consisting of capacitor C552, diode D568, diode D589
20 and capacitor C557. The charge pump 70 drives the gate of transistor Q527 above supply rail 29 to turn on MOSFET Q527. This connects the positive terminal of the battery B500 to the positive rail 29. KEEPON is maintained until the main microprocessor turns it off in response to an external command from the digital network local exchange, or an
irrecoverable system failure occurs. Additionally, when the power supply 20 is operating
25 from the backup battery B500, the microprocessor of the private exchange will pull KEEPON low if the battery voltage drops below 10.5 volts. A self-protection circuit in monitor 38 cuts off at 10.4 volts whether or not the microprocessor has commanded "off." This prevents over-discharge of the battery and eliminates erratic behavior of the private exchange due to an insufficient power supply from the battery.

30 The monitoring circuit 38 utilizes integrated circuits U504, U505 and U506. IC U504 is a current source biasing voltage regulator U505 to output a highly accurate reference voltage at 10 volts DC. Integrated circuit U504 is powered from the 13 volt supply rail 100 output of the pulse-width-modulator 30 through a diode D552. The

integrated circuit U504 is also connected to the VCC input of integrated circuits U515 and U516 through diode D542. When power is input through connector J6, the voltage level at the VCC input of integrated circuits U515 and U516 will exceed the 13 volt supply output. Accordingly, diode D542 is forward biased and power is supplied from supply rail

5 29 to U504. When the standby battery B500 is the power source, terminal 29 will fall below the 13 volt regulated output. Diode D552 will thus be forward biased to select the 13 volt output as the power source. The reference voltage provided by IC U505 from the main power output or the 13 volt output is used for battery voltage regulation and for monitoring during backup battery conditions.

10 The monitoring circuit includes a thermistor R549 which provides temperature compensation in the voltage divider. The impedance of thermistor R549 changes the voltage level at the terminals of the voltage divider when its impedance changes. The terminal voltage has a negative temperature coefficient of 18 millivolts per degree Celsius, which is the temperature characteristic of thermistor R549 in parallel with resistor R525.

15 An op-amp U507A has an input connected to the regulated 10 volt output of integrated circuit U505 through resistors R536 and R554. The inverting input of comparator U507A is connected to the reference potential at junction 102 between resistor R547 and R526. Low power operational amplifier U507A compares the voltage at junction 102, which varies with the temperature of thermistor R549, to the 10 volt reference. Amplifier U507 drives transistor Q502, which sinks current according to the output of amplifier U507 when below a threshold current level to regulate the battery charge voltage as a function of temperature. This insures that the battery will have an optimum charge level at different ambient temperatures. The threshold current limit is set by resistor R542 and the forward voltage drop of diodes D529 and D530.

20 25 A quad comparator U506, which may be implemented by a commercially available comparator U508, such as an integrated circuit LM339, monitors the battery status. The first comparator in comparator U506 compares the potential at the negative terminal of the battery input through resistor R563 to ground potential. When the power supply 20 goes to standby battery, the negative terminal of the battery is connected just below ground by Schottky diode D527. The inverting input (pin 6) of comparator 1 is then at -.3 volts. When connected to a power supply through connector J6, the inverting input (pin 6) is several volts above ground. The output of the first comparator (pin 1) of integrated circuit U508 thus has an ONLINE signal which identifies whether the system is connected to a

main power supply. Three additional comparisons are made to notify the system of the battery state when the backup battery is the power source. When the battery output reaches 11.4 volts, the battery is approximately 70% discharged and a signal output at pin 13 indicates this condition. This output is connected to NANDgate U517C, which outputs 5 a BSTAT 2 signal indicating a 30% battery charge remains. When the battery output voltage drops to 10.5 volts, the comparator LM339 outputs a signal at pin 14 which indicates that a shutdown is impending. NANDgate U517D outputs a system signal BSTAT2 indicating this condition. When the output voltage drops to 10.4 volts, the output of pin 2 drops to a low logic level which turns transistor Q512 off, shutting down 10 the power supply. Hysteresis is provided around the 10.5 and 11.4 switch points by resistors R595 and R602 (for the 10.5 volt reference), and resistors R596 and R603 (for the 11.4 volt reference). Additional hysteresis is provided by NANDgates U517C and U517D, as filtered by capacitors C568 and C569.

A reference frequency generator 41 outputs frequencies which are locked to a 256 15 KHz reference derived from the digital network local exchange to which the private exchange is connected through a subscriber loop of the telephone system. Integrated circuit U512 is used to implement a phase lock loop which operates in conjunction with resistors R531, R550 and capacitor C532 to determine the approximate operating frequency of the oscillator therein. The output frequency of pin 4 is input to integrated 20 circuit U513. Alternatively, a fixed 12.288 MHz can be used at the output of crystal Y1. Pin 8 of integrated circuit U513 is connected to the voltage controlled oscillator output pin 4 of integrated circuit U512. The output QA of integrated circuit U513 is connected to the clock input of integrated circuit U514. U513 is a divide-by-twelve counter and integrated circuit U514 is a binary counter. The output signal at pin 13 (QB) is fed back 25 to the comparator input of integrated circuit U512. The comparator output is filtered by resistor R562, resistor R504 and capacitor C512 to provide a control signal for the voltage controlled oscillator internal to integrated circuit U512. U514 further divides the feedback signal by four. The 12.288 MHz clock signal output at pin 4 of integrated circuit U512 is utilized by the ringing signal generator. The 64 KHz clock signal is used by integrated 30 circuits U515 and U516. These frequencies are thus phase locked to the local exchange frequency of 256 KHz to minimize noise and beat notes in the private exchange which would otherwise occur.

Thus, it can be seen that a power supply is disclosed which provides a plurality of voltage levels and control signals for a digital network private exchange. The power supply includes functions of current limiting and selective power conservation. The power supply also interfaces with the private exchange control system to provide additional 5 control over the power supply without adding to the overall cost of the private exchange hardware. The power supply operates at a frequency phase locked to the ISDN network clock to help eliminate noise in the system.

It is to be understood that the foregoing description of the preferred embodiments of the invention is provided for purposes of description and illustration, and not as a measure 10 of the invention, whose scope is to be defined by reference to the ensuing claims. Thus, those skilled in the art may devise embodiments of the particular concepts presented in the foregoing illustrative disclosure which differ from the particular embodiments shown and described in detail herein or may make various changes and structural details to the illustrated embodiments. Accordingly, all such alternative or modified embodiments which 15 utilize the underlying concepts of the invention and incorporate the spirit thereof are to be considered as within the scope of the claims appended hereinbelow, unless such claims, by their language, specifically state otherwise.

CLAIMS:

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A power supply for a digital network private exchange, comprising:
 - an input connectable to a main power source through a standard AC wall outlet
 - 5 having an AC voltage magnitude less than approximately 240 volts;
 - a first converter connected to said input to receive a power supply therefrom, and including a first PWM controller including power factor correction such that said power converter maximizes the performance of circuit components connected to said power supply input, said first converter generating a preregulated supply voltage at an output; and
 - 10 a second converter circuit coupled to said output of said first converter for generating a plurality of different regulated supply voltages from said preregulated supply voltage.
2. The power supply as defined in claim 1, wherein said first power converter includes
 - 15 energy storage components coupled to said input which are selectively charged under the control of said first PWM controller.
3. The power supply as defined in claim 1, wherein said second converter includes a second PWM controller coupled to said output of said first converter and including a
 - 20 plurality of outputs at which respective ones of said supply voltages are output.
4. The power supply as defined in claim 3, further including a ringing signal generator coupled to at least one output of said power converter for selectively generating a ringing signal.
 - 25
5. The power supply as defined in claim 4, further including a third converter including a third PWM controller having a plurality of outputs at which respective supply voltages are output.
- 30 6. The power supply as defined in claim 5, further including a backup power source for providing power to said second and third power converter circuit when said main power source is interrupted.

7. The power supply circuit as defined in claim 6, further including a detector for sensing whether said main power source or said backup power source is energizing said second and third power converters.

5 8. The power supply as defined in claim 7, further including a controller for selectively disabling said third power converter during backup power source operation.

9. The power supply as defined in claim 6, further including a status monitor coupled to said backup power source, said status monitor generating signals identifying the status
10 of said backup power source.

10. The power supply circuit as defined in claim 9, wherein said status monitor outputs a control signal indicating said main power source is interrupted when said backup power source becomes the power source for said second and third converters.

15 11. A power supply for a private exchange, comprising:
an input connected to a main power source;
a first regulator coupled to said input and having an output;
a backup battery;
20 a first switch coupled to said output of said first regulator and to said backup battery, said first switch selectively coupling said output to said backup battery; and
a circuit coupled to said power supply and to said first switch, said circuit outputting a signal which controls said first switch to disconnect said battery from said output during initial power-up of the power supply, and connecting said output to said
25 output after a predetermined threshold is reached.

12. The power supply as defined in claim 11, further including a fuse coupled to said battery.

30 13. The power supply as defined in claim 12, further including a current sink coupled to said fuse to control the charging current through said backup battery.

14. The power supply as defined in claim 11, wherein said first switch includes a transistor connected between said backup battery and said output of said first regulator.

15. The power supply as defined in claim 14, wherein said transistor is a MOSFET.

5

16. The power supply as defined in claim 14, further including a second regulator coupled to said output and generating a plurality of output supply voltages.

17. The power supply as defined in claim 16, wherein a control input of said transistor
10 is connected to an output of said second regulator.

18. The power supply as defined in claim 17, further including a charge pump connected between said output of said second regulator and said control input of said transistor.

15

19. The power supply as defined in claim 11, further including a second switch connected between said first regulator output and a supply input of said second regulator.

20. The power supply as defined in claim 19, further including a threshold detector
20 coupled to said first regulator and to said second switch, and wherein said threshold detector controls said second switch to connect said first regulator output to said supply input of said second regulator when said first regulator reaches a predetermined threshold following power up.

25 21. The power supply as defined in claim 20, further including a second input coupled to said transistor for holding said transistor on after power-up.

22. The power supply as defined in claim 19, further including a monitoring circuit and a third switch coupled to said first regulator output and said monitoring circuit, said third
30 switch selectively connecting said monitoring circuit to said first regulator output.

23. The power supply as defined in claim 22, further including a threshold detector coupled to said first regulator and said third switch, and wherein said threshold detector

controls said third switch to connect said first regulator output to said monitoring circuit when said first regulator output reaches a threshold following power up.

24. A power supply for a private exchange connected to a digital network, comprising:

5 an input circuit connected to a main power source for inputting power;
a switched power converter coupled to said input circuit for generating a regulated output voltage from said input power, said first power converter including a controlled switch and at least one storage component coupled to said input power through said switch for generating a plurality of regulated supply voltages, said switch controlled as a function
10 of a local clock signal; and

15 a clock signal generator, receiving a network clock signal from the digital network and outputting said local clock signal such that said local clock is phase locked to the digital network clock to reduce power supply noise in the private exchange.

25. The power supply as defined in claim 24, wherein said clock signal generator includes a phase-locked-loop.

26. The power supply as defined in claim 25, further including a reference signal generator including a crystal oscillator coupled to said clock signal generator.

20 27. The power supply as defined in claim 24, wherein said power converter includes a first PWM controller having an input coupled to said clock signal generator and an output coupled to at least one of said at least one storage elements.

25 28. The power supply as defined in claim 27, further including a second power converter, said second power converter including a second PWM controller having an input coupled to said clock signal generator.

29. The power supply as defined in claim 28, further including a switch coupled
30 between said second PWM controller and said clock signal generator for selectively inputting said clock signal to said controller.

30. The power supply as defined in claim 29, further including a ringing signal generator generating a ringing signal at an output thereof and coupled to said clock signal generator whereby said ringing signal is phase locked to the digital network clock.

5 31. A power supply for an integrated services digital network private exchange, comprising:

a main power source input circuit having a power supply output coupled to a supply rail;

10 a backup battery coupled to said supply rail such that said backup battery is charged from the main power source when the main power source is uninterrupted;

a temperature sensor coupled to said supply rail and detecting an ambient temperature; and

15 a regulator coupled to said battery and to said temperature sensor for regulating the current supplied to said battery as a function of the detected ambient temperature so as to maximize the life of the battery.

32. The power supply as defined in claim 31, wherein said regulator includes a current sink coupled to said battery.

20 33. The power supply as defined in claim 32, wherein said current sink includes a transistor coupled to said battery and having a base coupled to said temperature sensor.

34. The power supply as defined in claim 33, further including an amplifier coupled to said temperature sensor and to a reference signal for comparing a signal of said 25 temperature sensor to said reference signal and outputting a signal to said current sink as a function thereof.

35. The power supply as defined in claim 34, wherein said temperature sensor includes a thermistor connected in series with at least one impedance element.

30

36. A power supply for a digital network private exchange comprising:
a main power source input;
a backup power source;

a power converter circuit coupled to said main power source input and to said backup power source, said power converter generating a plurality of supply voltage levels for the private exchange;

means for detecting when the backup power source is the power source for the
5 private exchange; and

means for turning off selected power supply functions to conserve said backup power source while supplying sufficient power to the private exchange to permit external communication when said backup power source is the power supply for the private exchange.

10

37. The power supply as defined in claim 36, wherein said means for turning off said power supply functions includes a first switch which interrupts at least a first supply voltage at a respective output of said power converter when said backup power source is the power source for the private exchange.

15

38. The power supply as defined in claim 37, further including a second switch which selectively connects a secondary supply voltage to said respective output to replace said first supply voltage when said first supply voltage is interrupted.

20

39. The power supply as defined in claim 36, further including a ringing signal generator coupled to said power converter circuit, said ringing signal generator outputting a ringing signal.

25

40. The power supply as defined in claim 39, wherein said means for turning off power supply functions includes a switch which selectively interrupts the supply voltage coupled to said ringing signal generator when the backup battery is the source for the private exchange.

30

41. The power supply as defined in claim 40, wherein said power supply converter includes a plurality of PWM controllers, one of said PWM controllers generating an output voltage input to said ringing signal generator, and said switch is connected to a clock input of said one of said PWM controllers to selectively interrupt a clock input signal when said power backup battery is the power source for said one of said PWM controllers and said

ringing signal is not being generated, whereby said one of said PWM controllers is disabled.

42. A power supply for a private exchange, comprising:

5 a power supply input circuit coupled to a main power source and outputting a preregulated supply voltage;

 a monitor detecting whether said power supply input circuit is energized by the main power source;

10 a voltage and current regulation circuit coupled to said power supply input circuit and producing a plurality of regulated supply voltages at respective outputs; and

 a control circuit coupled to said voltage and current regulation circuit and said monitor to control said regulation circuit outputs.

43. The power supply as defined in claim 42, further including a backup power source,

15 one of said main power source and said backup providing power for the power supply,

 wherein said sensor inputs a control signal indicating which of the power sources is the

power supply, and wherein said control circuit adjusting said supply voltages depending on

the one of said power sources energizing the power supply.

20 44. The power supply as defined in claim 43, wherein one of said supply voltage

outputs is coupled an interface circuit in the private exchange, and said control circuit

controls said one of said supply voltages according to the load presented on said one supply voltage output.

25 45. The power supply as defined in claim 44, wherein said power regulator includes a

foldback current limiter coupled to said one of said supply voltage outputs for limiting the

current input to said one of said outputs such that said one of said outputs is disabled in a short circuit condition.

30 46. The power supply as defined in claim 44, wherein said control circuit includes a

current limiter coupled to said one of said supply voltage outputs for automatically

limiting a current at said one of said outputs to a fixed, predetermined non-zero level.

47. The power supply as defined in claim 44 wherein said one of said supply voltage outputs is reduced to a fixed predetermined lower level when a backup power source is the power supply for the private exchange.

5 48. A power supply for a digital network private exchange comprising:
a power source generating a regulated positive DC output signal and a regulated negative DC supply voltage;
a digital signal generator having an input coupled to a controller and first and second digital outputs having first and second control signals thereon;
10 first and second optical couplers connected to said first and second outputs of said digital signal generator;
totem pole transistors coupled to said outputs of said optical couplers for generating a sinusoidal ringing signal at a junction of said transistors; and
a filter coupled to said junction for filtering the signal at said junction.

15 49. The power supply as defined in claim 48, wherein said digital signal generator has an input connected to a timing signal generator which outputs a timing signal in phase with a local exchange data signal.

20 50. The power supply as defined in claim 49, wherein said filter includes an energy storage component and said power supply further including a switch coupled to said energy storage component in said filter for selectively discharging said storage component.

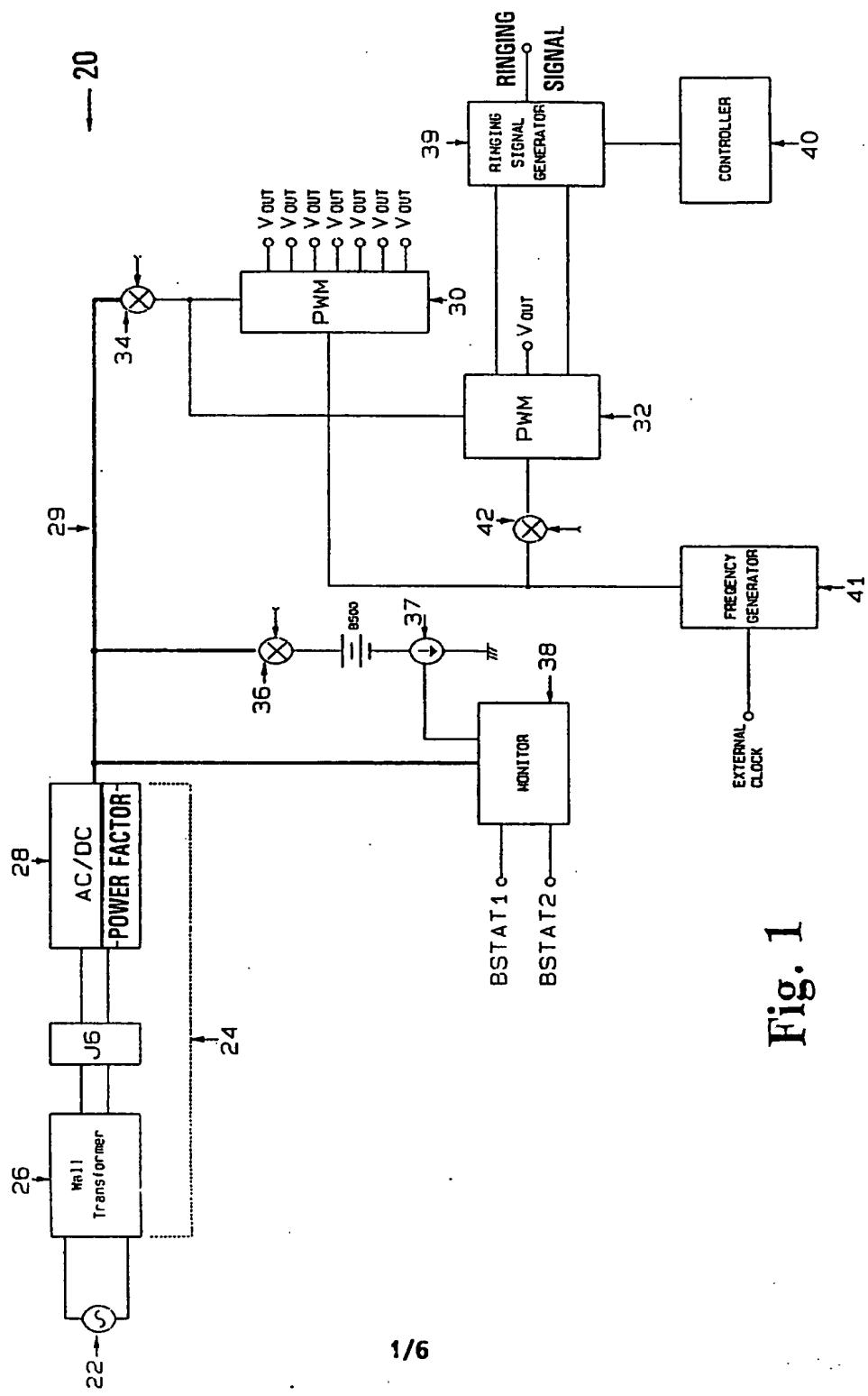
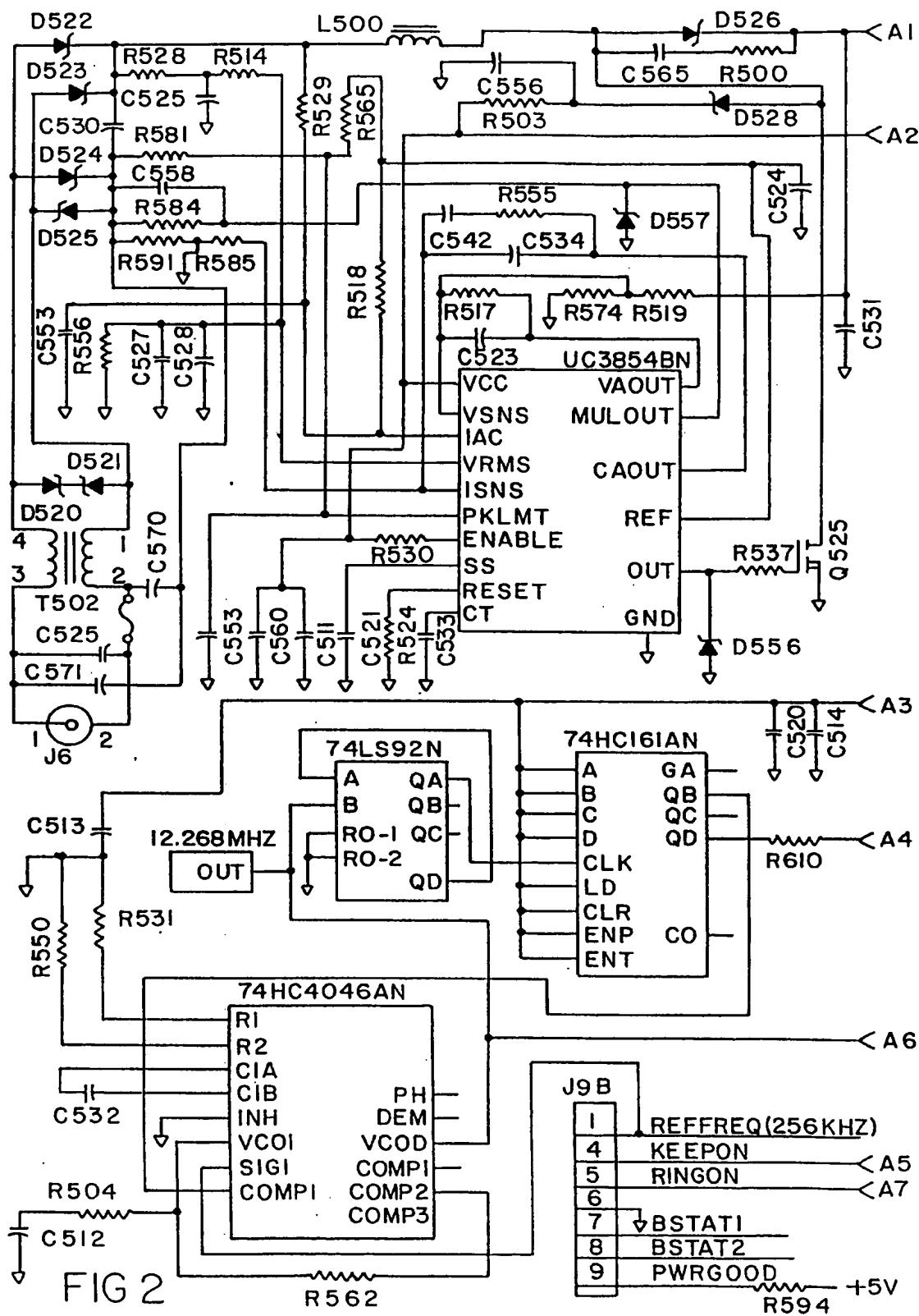


Fig. 1



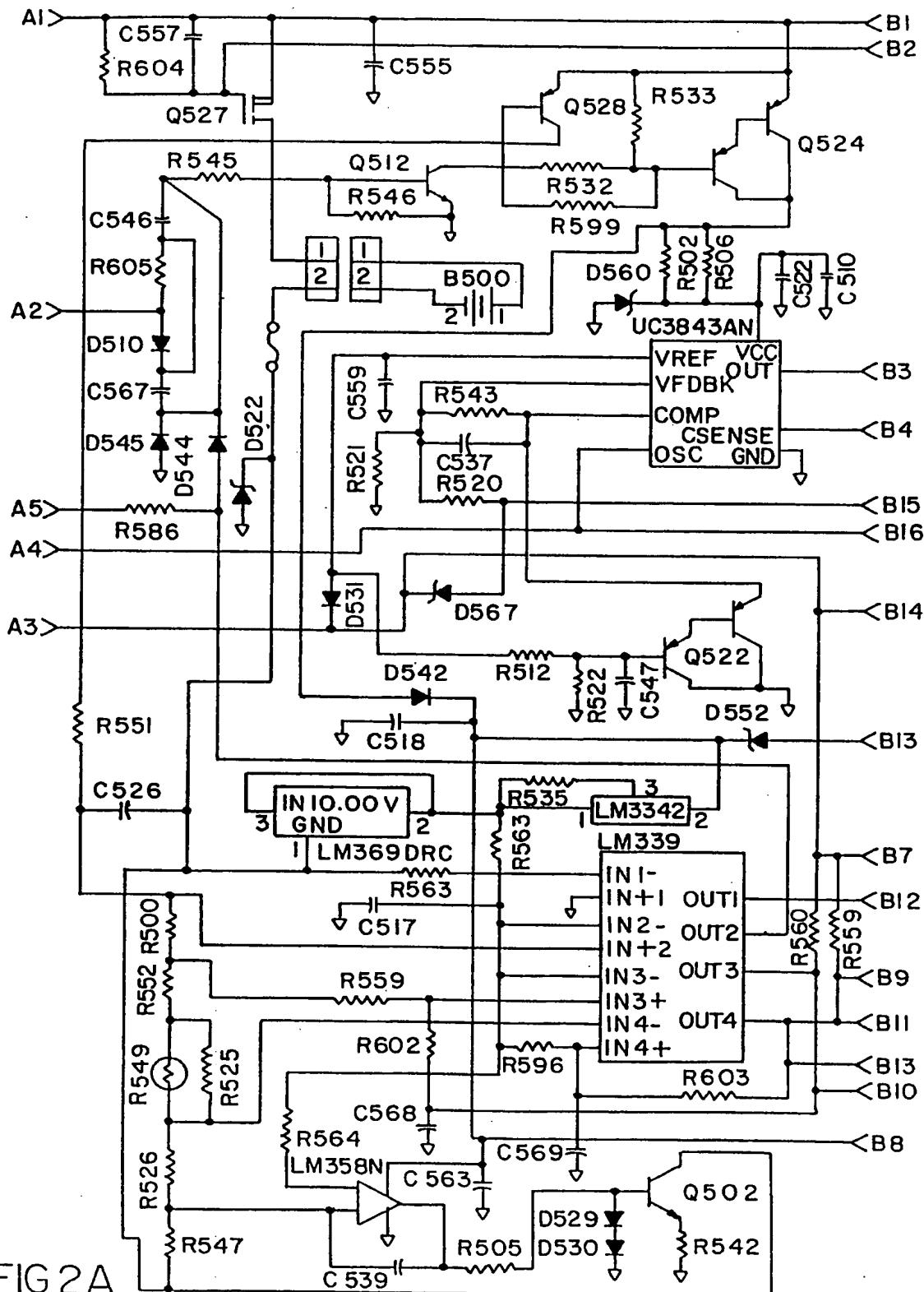


FIG 2A

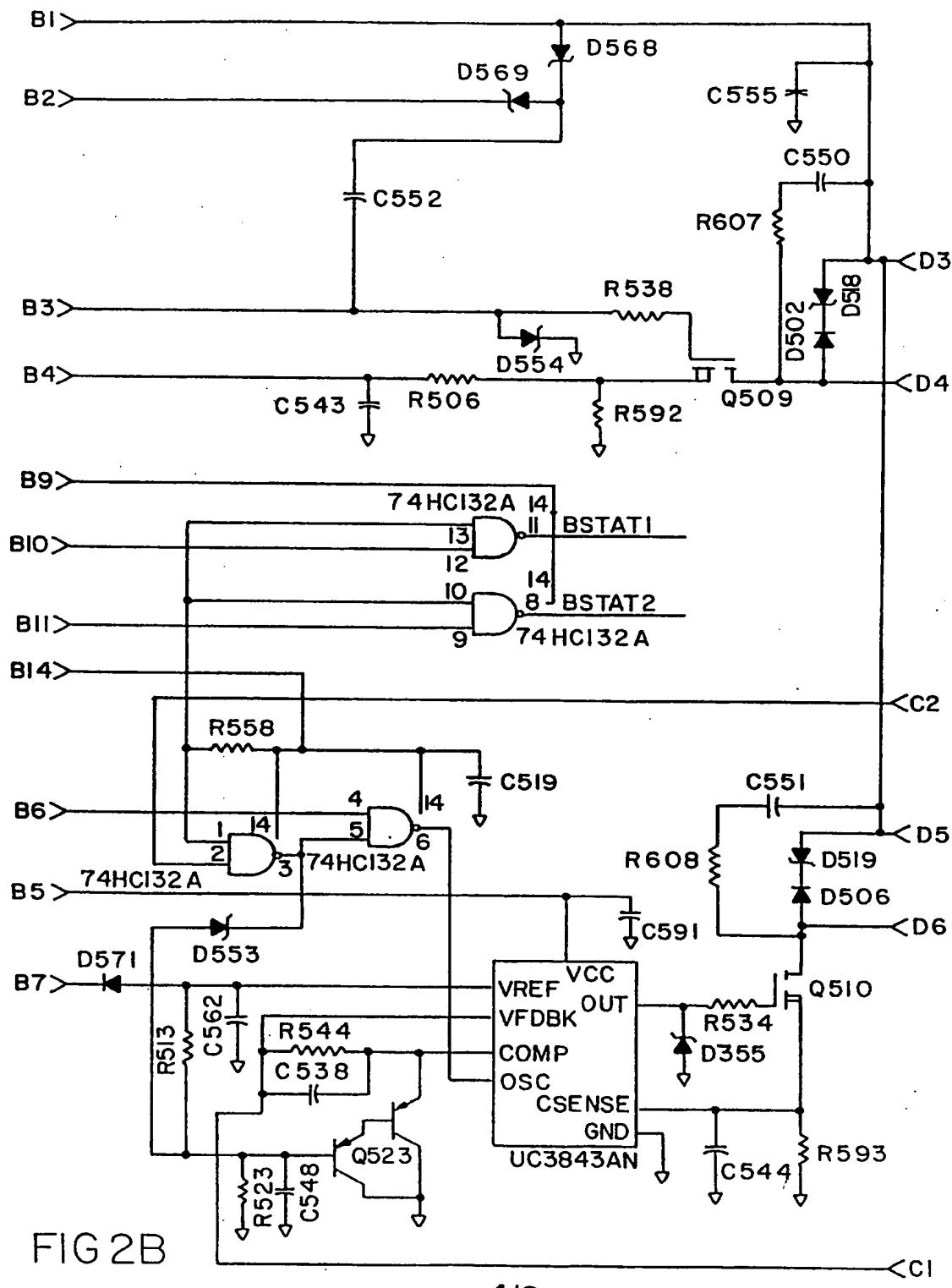
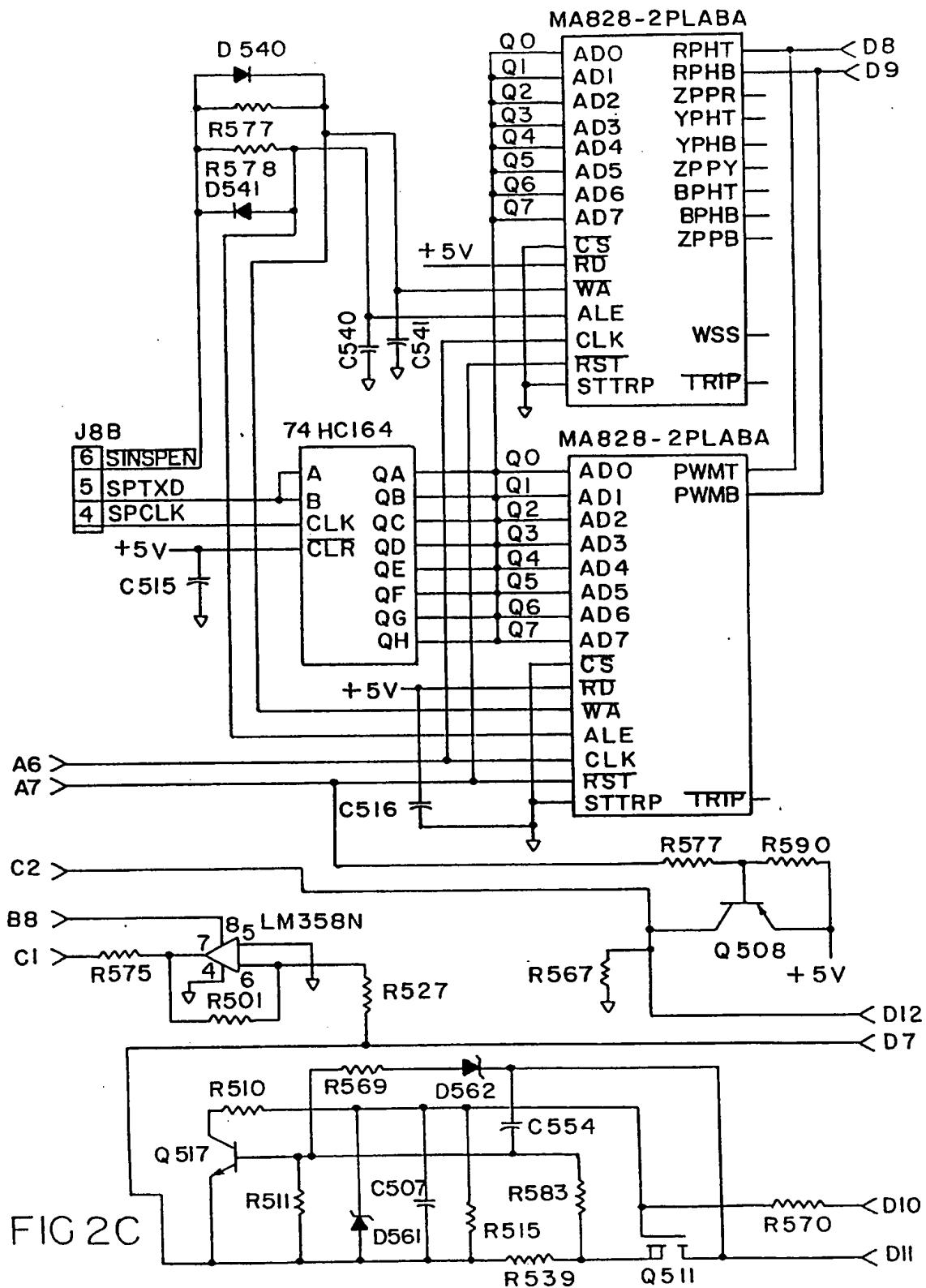
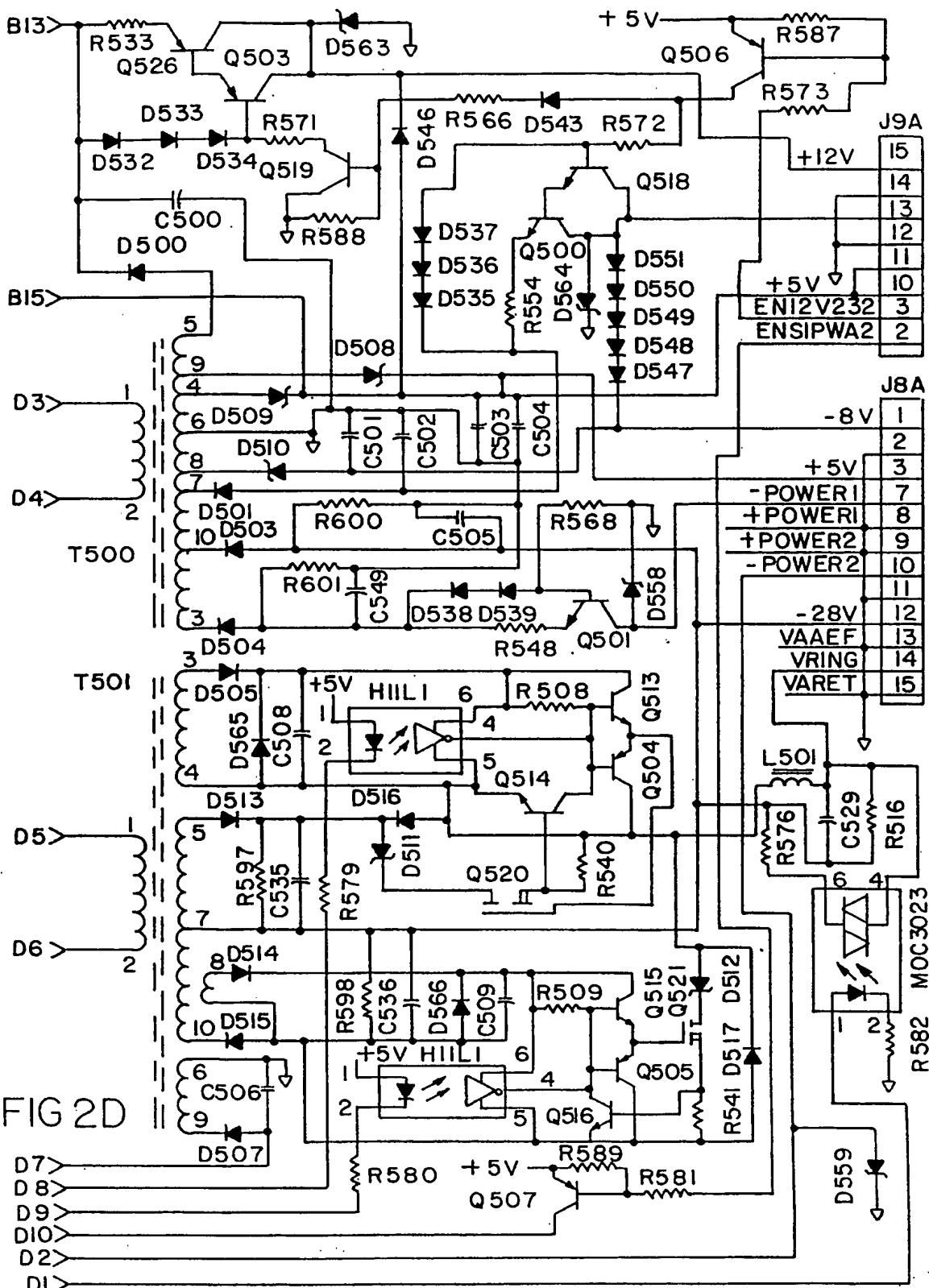


FIG 2B

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SUBSTITUTE SHEET (RULE 26)





INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/01348

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H02M 1/12, H04M 1/00, 1/60; H02J 7/00
US CL :363/39,41,62; 379/176,412,413; 407/46,48,66,82

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 363/39,41,62; 379/176,412,413; 407/46,48,66,82

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS: PRIVATE (6W) EXCHANGE; PWM; BATTERY

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,575,585 (BROWN) 11 MARCH 1986 SEE FIG. 2	1-50
Y	US, A, 4,808,905 (CHEN ET.AL.) 28 FEBRUARY 1989 SEE FIG. 1	11-50
A	US, A, 4,535,202 (MEUNIER) 13 AUGUST 1985 SEE FIG. 1	1-50
A	US, A, 5,060,241 (ALLOUIS ET AL.) 22 OCTOBER 1991 SEE FIG. 1	1-50
A	US, A, 3,952,172 (PENN ET AL.) 20 APRIL 1976 SEE FIG. 1	1-50

Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:	T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
A document defining the general state of the art which is not considered to be of particular relevance	X	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
E earlier document published on or after the international filing date	Y	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	&	document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means		
P document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

15 MAY 1995

Date of mailing of the international search report

26 MAY 1995

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